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Natural Resources: Water: A New Liquid Gold*

> The Resource becomes scarce. Shortages occur locally, perhaps even nationally. People wait in lines, sometimes for hours, to replenish their supply. Prices soar and the cost of food and countless other products made from the Resource rise. People learn to get along with less. They worry that someday there will not be enough of the Resource to go around.[1]

This resource could be gasoline or oil; it could also be water. The public has come to expect abundant, clean, safe, and inexpensive water at the turn of the tap.[2] Though it is inconceivable to many of the world's other inhabitants, Americans are accustomed to having unlimited supplies of water at their immediate disposal. Americans can, and do, needlessly allow hundreds of gallons of water a year to run down drains while brushing their teeth, washing their cars, or watering their lawns, thinking nothing of it.[3] Water is one of the natural resources essential to the existence of life on earth. Human dependency on this precious resource has gradually increased from being primarily a thirst quencher for primitive peoples to an indispensable requirement for the daily comforts and necessities of modern civilization. Agricultural production, industrial operations, household conveniences and duties, and even recreational fulfillment depend on water.[4]

Studies indicate that the United States has an abundance of fresh surface and groundwater. These resources have been developed and used extensively. The renewable (long-term) supply of water in streams and aquifers is approximately 1,400 billion gallons per day (for the conterminous United States). That is more than three times the present rate of fresh water withdrawal in the nation, and about fourteen times the national consumptive use of water.[5]

Statistically, the U.S. should not have a water problem. Few people, however, can argue that the United States' water supply is evenly distributed. Nature's uneven distribution has triggered water supply disputes in arid sections of the country. It has also contributed to waste and mismanagement of water resources in sections where water is plentiful.[6] From the bone-dry deserts of the West to the lush fields of the Northeast, conflicts over water are erupting with increasing frequency. It is a war pitting region against region, state against state, city against city.[7]

* This paper was awarded the Eugene Kuntz Oxford Scholarship for 1986 as being the best paper in the area of Natural Resources Law.

1. L. PRINGLE, WATER: THE NEXT GREAT RESOURCE BATTLE 7 (1982).
2. U.S. GEOLOGICAL SURVEY, NATIONAL WATER SUMMARY 1983—HYDROLOGIC EVENTS AND ISSUES 4 (1984).
3. Powledge, *Water, Water, Running Out*, 234 THE NATION 703 (June 12, 1982).
4. O'Meara, *A National Water Crisis: Can It Be Avoided?*, RECLAMATION ERA 5 (Apr. 1983).
5. U.S. GEOLOGICAL SURVEY, *supra* note 2, at 1.
6. O'Meara, *supra* note 4, at 6.
7. *War Over Water—Crisis of the '80's*, 95 U.S. NEWS & WORLD REP. 57 (Oct. 31, 1983).

The coming crisis goes beyond the availability and competition for water. The most dramatic of the current and recent troubles deal with the quality of the available water supply. Americans have abused the earth's enormous, but finite, supply of water for a long time.[8] Groundwater supplies one-fourth of all fresh water used in the United States. It is the primary source of drinking water for nearly one-half the population of the United States. Thus protecting the quality of groundwater supply is a major concern at all levels of government.[9]

Of all the types of pollution that are steadily degrading man's physical environment in the United States, the least recognized is the hidden deterioration in the quality of groundwater—the vast subsurface water reservoir that is of vital importance to cities, industries, agricultural enterprises, and private homeowners across the nation. Although the dumping of liquid wastes into the ground has been going on insidiously for a long time, the evidence of damage to groundwater quality has only begun to show up in recent times.[10] The many incidents of groundwater contamination reported in recent years have cast doubt on the safety of this once untainted water source. Once polluted, groundwater may remain contaminated for centuries. Cleansing techniques are costly and have limited effectiveness.[11]

As the United States population grows, dependency on supplies of potable water, that is, suitable for drinking, grows even faster. The underground aquifers' inability to sustain this growing demand has already become evident in some regions of the United States. This, coupled with the discovery of the presence of contaminants and pollutants in these supplies, may make shortages more prevalent and competition for water more intense. The situation, as it stands now, has been described as "a bomb sitting there ready to explode."[12]

This paper will consider the competition for water rights in light of the availability and quality components. Further, it will discuss other factors that play a role in the attempts to obtain and protect this precious resource. Finally, it will consider the water crisis in Oklahoma and the state's attempts to solve its water resource problems.

Surface Water—Not Enough for Everybody

The quantity of water transported by the hydrologic cycle is illustrated by the "gross water budget" of the conterminous United States, as shown in Figure 1. Of the approximately 40,000 billion gallons per day (bgd) of water vapor that passes over the United States, about 4,200 falls as precipitation. About two-thirds of this precipitation (2,800 bgd) is returned to the atmosphere

8. F. POWLEDGE, WATER (1982).

9. T. HENDERSON, J. TRAUBERMAN & T. GALLAGHER, GROUNDWATER: STRATEGIES FOR STATE ACTION 1 (1984).

10. GERAGHTY & MILLER, INC., GROUNDWATER CONTAMINATION 1 (1972).

11. HENDERSON, TRAUBERMAN & GALLAGHER, *supra* note 9, at 1-2.

12. U.S. WORLD & NEWS REP., *supra* note 7, at 57.

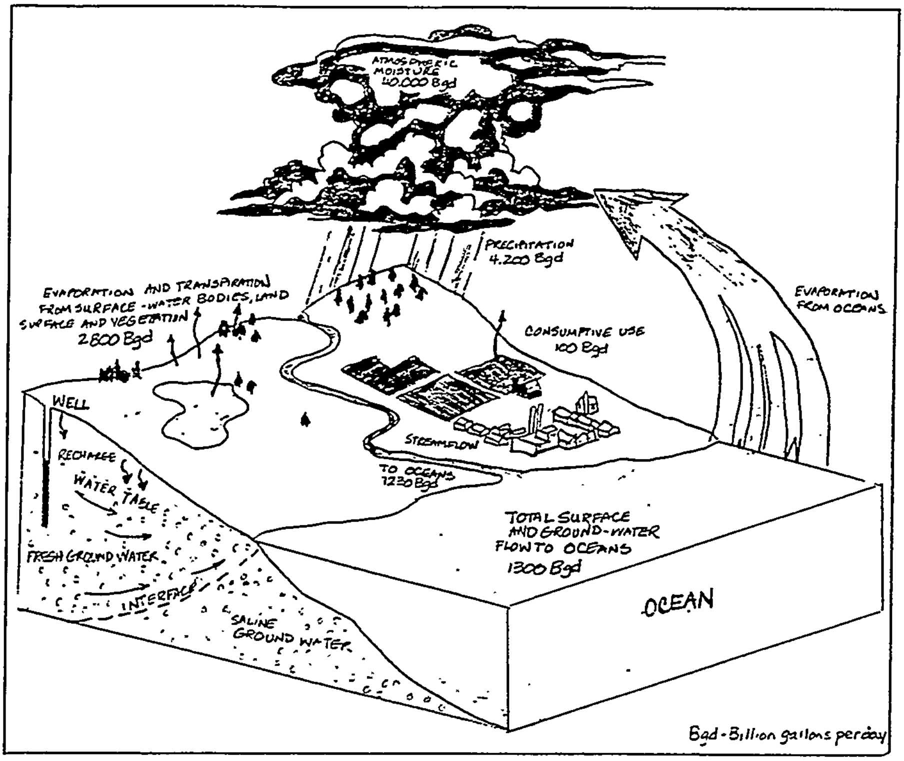

Figure 1. Hydrologic cycle showing the gross water budget of the conterminous United States Source: United States Geological Survey.

through evapotranspiration—loss of evaporation from a land area through transpiration of plants and evaporation from the soil and water surfaces. The remaining 1,400 bgd, depending upon the properties of the land surface, soils, and vegetation, discharges directly to streams and lakes, or to the ocean, or seeps into the ground, where it goes into storage and subsequently discharges to surface water bodies. During its journey to the ocean, some of this water is withdrawn from aquifers and streams for various uses by man, returned to its source (usually to streams), and withdrawn again, several times. These uses and reuses of water involve the total withdrawal of approximately 380 bgd of fresh water, of which about 100 bgd is consumptively used. The total amount of water that returns to the ocean is about 1,300 bgd.[13]

Of the total fresh water on the surface and underground, only about 5 to 7 percent is used by people. Figure 1 and the statistics indicate that talk of water shortages is unfounded. The talk, however, is serious, and the threat of severe regional water shortage is real.

13. U.S. Geological Survey, *supra* note 2, at 8-9.

The nation's rain and snow do not fall evenly across the land. Although the national average is 30 inches of annual precipitation, states east of the Mississippi never receive more than 40 inches. Parts of the Pacific Northwest receive 80 inches, but most of the West is water-poor. Eastern Nebraska receives 27 inches, but the western part of the state gets only 18 inches. Nevada, the driest state, gets only 9 inches. Overall, the West, with 60 percent of the nation's land, gets only one-quarter of its total annual precipitation.[14]

The rivers and streams of the nation are a major source of America's water supply. In much of the country, streamflow is a direct result of rainfall. In the West, however, it is also the result of snowmelt in the mountains, which each spring fills streams and reservoirs. In the Southwest, as much as 75 percent of the annual runoff occurs during a few weeks in the spring when mountain snows melt.[15]

Inadequate winter snowfall, shortages of rain, and summer drought further reduce the short supply in the water-poor West. With inadequate surface waters, there is not enough water to meet the demands of agriculture and other users.[16] As statistics of the Department of Agriculture indicate, in a year of average rainfall and snowmelt, much of the western U.S. depletes the available surface water supply by 70 percent. Further, another large area of the West experiences a 70 percent depletion in a dry year.[17] In the agriculturally rich Middle West, shortages of water greatly affect the farmers' ability to properly irrigate valuable crops. The problems of availability or quantity of water has traditionally been considered a problem of the West. Although blessed with plenty of rain and snow, even the eastern half of the U.S. is beginning to feel some of the pressures that have been felt in the West from a lack of available water.[18]

Crucial to any water supply are dams and reservoirs that store and save water until it is needed. Reservoirs in the United States can store 225 trillion gallons of water. There are some 49,000 large reservoirs and more than two million small reservoirs in this country, but just thirty-one of these account for 41 percent of the nations' total reservoir storage capacity.[19]

Unfortunately, in the eastern U.S. little development of water storage facilities has taken place in the past few decades. Most federal money available for reservoir development went to the West and the South. In 1978, for example, the amount of federal money given to Idaho for water projects equaled $76.88 for each state resident. In contrast, the per-capita share in New York was 15 cents.[20] Addressing the public money spent on western water projects, Mayor Edward Koch of New York City said, "They have these multiple-purpose projects out there that combine irrigation, flood control,

14. PRINGLE, *supra* note 1, at 17.
15. U.S. DEP'T OF AGRIC., AMERICA'S SOIL AND WATER: CONDITIONS AND TRENDS 23 (1981).
16. *Id.*
17. *Id.*
18. U.S. NEWS & WORLD REP., *supra* note 7, at 60.
19. U.S. DEP'T OF AGRIC., *supra* note 15, at 23.
20. PRINGLE, *supra* note 1, at 22-23.

and recreation—so they make out like bandits. Well, we can't have water-skiing in our city tunnels. If I could figure out a way to put canoeists down there, maybe our problems would be solved."[21]

In New York City, like other older eastern cities, water supply problems have been developing for decades. Many water distribution systems and sewer lines were laid in the 1800s and early 1900s. Life expectancies of such systems were fifty to seventy-five years. Needed modernization was delayed by the Great Depression and again by World War II.[22] Many eastern cities have been hit hard by recessions and the flight of industry to the Sun Belt. Now there is little money to repair or replace the old, antiquated water delivery systems.[23]

New York City's underground-tunnel water-delivery system, built in 1917 and 1936, currently carries 60 percent more water than the tunnels were designed to carry. A third tunnel was planned in the 1950s to stave off any supply problems. Construction began in 1970, and the 60-mile tunnel was supposed to be finished in 1977. By 1981, however, only 11 miles had been completed. The project to that point had been financed solely by the city.[24] The inability to obtain additional federal loan money led to Mayor Koch's earlier quoted remarks and set up what one official calls "a scenario for disaster" if one of the existing tunnels fails. A failure would leave millions of people without water for weeks or months, and business centers would be shut down.[25]

Other eastern cities face similar possibility for disaster as they struggle to replace old systems or to increase storage capacity. Some communities in New Jersey lose as much as 40 percent of their water before it reaches the tap because of leaking pipes. In 1983 forty communities in Massachusetts ordered curbs on water use for a period of time because of shortages. The major problem was insufficient storage capacity, not a lack of precipitation. As one state official observed: "You can have all the precipitation in the world, but it doesn't do any good if you can't store it."[26]

Bottom of the Well

America's groundwater resources supply one-fourth of all fresh water used in the United States and is the primary source of drinking water for nearly one-half the population of the United States. Concern with protecting groundwater supplies and public health has made groundwater quality protection a growing concern.[27]

America's groundwater resources are far greater than the total capacity of all the United States lakes and reservoirs, including the Great Lakes. The

21. *Id.*
22. *Id.* at 20.
23. U.S. NEWS & WORLD REP., *supra* note 7, at 60.
24. PRINGLE, *supra* note 1, at 20-23.
25. U.S. NEWS & WORLD REP., *supra* note 7, at 60.
26. *Id.*
27. HENDERSON, TRAUBERMAN & GALLAGHER, *supra* note 9, at 1.

volume is equivalent to about thirty-four years of surface runoff. Groundwater includes vast underground lakes, like the great Ogallala aquifer that underlies parts of eight Great Plains states.[28] Stretching 800 miles, the aquifer is the main water supply for major parts of six states—Texas, New Mexico, Oklahoma, Colorado, Kansas, and Nebraska.[29]

Most aquifers, like the Ogallala, were formed from five to twenty-four million years ago. Water from the plentiful rainfall of that prehistoric time was trapped between a layer of rock on top and a bottom layer of shale. The Ogallala may be the largest underwater reserve of fresh water on earth. It holds an estimated 2 billion acre-feet of water. Most of the Ogallala's water is millions of years old and is replenished little by the region's sparse rainfall (between 10-30 inches per year).[30] An average of only three inches of the water that soaks into the ground each year passes beyond the soil moisture zone and recharges groundwater supplies.[31]

Groundwater pumpage has steadily increased over the last three decades, according to U.S. Geological Survey data. The total pumpage of groundwater in 1980 represented about 20 percent of the total withdrawal of fresh and saline water in the United States. The distribution of withdrawals by state, including the relative proportions of surface and groundwater withdrawn, is documented by the U.S.G.S. Surveys show groundwater withdrawals exceed surface water withdrawals only in Arizona, Kansas, Nebraska, and Oklahoma. The withdrawals include both fresh and saline water. If only fresh water withdrawals are considered, nine states use more groundwater than surface water. These include Delaware, Florida, Hawaii, Mississippi, and Texas, in addition to those listed above.[32] Kansas, Oklahoma, Nebraska, and Texas take up the largest portions of the Ogallala aquifer.

About 200,000 wells now puncture the High Plains. They irrigate more than 10 million acres of agricultural land. Farmers are able to raise corn, cotton, and other crops that could not survive if watered only by rainfall. Moreover, 40 percent of all grain-fed beef sent to market in the United States is fattened in the High Plains region overlying the Ogallala aquifer.[33] This agricultural boom is dependent on the Ogallala aquifer. Other economies and regions are just as dependent on abundant groundwater resources as the High Plains.

There is nothing inherently wrong in using up groundwater in this way, but people in the High Plains region (and others) must face reality: their wells have bottoms. Nature's gradual and time-consuming recharge is slower than the consumption of the water and thus makes Ogallala's water like oil or any other mineral being pumped or mined from underground. In a sense, the water is being mined, and the aquifer will someday run dry.[34]

28. U.S. DEP'T OF AGRIC., *supra* note 15, at 24.
29. PRINGLE, *supra* note 1, at 70.
30. *Id.* at 68-69.
31. U.S. DEP'T OF AGRIC., *supra* note 15, at 24.
32. U.S. GEOLOGICAL SURVEY, *supra* note 2, at 28, 37.
33. PRINGLE, *supra* note 1, at 70.
34. *Id.*

Much of the western one-third of Kansas is a prosperous feed-grain economy dependent on irrigation from the Ogallala. Signs of depletion are now becoming evident in this area. Wells that formerly pumped water at the rate of 500 gallons a minute have been reduced to 300, sometimes less. As much as 2,000 pounds of water pressure have been lost, forcing restriction of the hours of water use. Peak demand for water is not always met. Changes in other areas of Kansas have also occurred in various degrees but has not yet met the harshness of the results experienced in areas of Texas.[35]

The depletion of the Ogallala in Texas shows how water and energy can become intertwined. Around Pecos, in northwest Texas, abandoned farmland is now littered with rusting irrigation pipes. This same area was once booming with agricultural activity, being described as a "Garden of Eden." Though the water table was known to be dropping, it was considered manageable because of low prices of natural gas used to drive the irrigation pumps. When fuel prices rose in 1973, many farmers quit the agriculture business, ending Pecos' boom. Though current prices of fuels are low, some day these resources will also run out. The unbreakable link between water and energy will greatly determine the future prosperity of the High Plains and similar areas.[36]

In extreme cases in Texas, exhaustion of the aquifer has already resulted in the land going back to sagebrush. Many farmers in Texas and other states using Ogallala water are now trying to alleviate the problem by growing alternate crops that require little water or by using more efficient drip-irrigation systems to avoid wasting water.[37] This has resulted in a shift from certain high-water requirement crops such as corn toward more dry-tolerant crops such as grain sorghum. Once a $170 million cash crop in Texas, corn has been predicted to "disappear from the Texas High Plains within the next few years."[38]

Texas law acknowledges that the underground water will eventually be depleted: farmers get a groundwater depletion allowance, just as wildcatters do for oil. Some argue this encourages waste. The more water pumped, the less tax paid by property owners. Virtually no other water-use regulations exist in Texas. Rules for spacing wells a certain distance apart have been established, but with no limits on water use. This sometimes acts as a negative incentive. After all, if property owners fail to conserve water while others around them do, the wasteful owners benefit in the short term in increased water consumption and tax savings.[39]

The land across the United States bears the scars of depletion of underground water. In Arizona, so much groundwater has been drawn up by Arizona cotton and alfalfa farmers that the desert floor between Tucson and Phoenix is laced with cracks up to twenty-five feet wide. For years, Houston has been sinking

35. Walsh, *What To Do When the Well Runs Dry*, 210 SCIENCE 754 (Nov. 14, 1980).
36. PRINGLE, *supra* note 1, at 75.
37. Walsh, *supra* note 35, at 754.
38. Adler, et al., *The Browning of America*, NEWSWEEK 34 (Feb. 23, 1981). See also Walsh, *supra* note 35, at 755.
39. PRINGLE, *supra* note 1, at 79.

as water was sucked from beneath it; California's San Joaquin valley, an immensely rich agricultural area, has dropped by nearly thirty feet in some places. The compacted subsoil has lost its capacity to hold water, so that even if pumping stopped, the aquifer could never fully recharge.[40] California maintains a wide margin over all other states for daily withdrawal of groundwater resources, approximately 24 bgd. Florida's massive pumping of groundwater supplies has resulted in huge sinkholes in areas as portions of land collapse after removal of water.

More Than Simple Demand

The decrease in both surface water and groundwater availability comes from more than just private consumer demand. Other factors greatly influence the amount of usable water. In fact, domestic and commercial use, steam electricity generation, manufacturing, mineral recovery, and public land use of water accounts for only 17 percent of fresh water withdrawals.[41] Agriculture is far and away the United States' biggest water consumer. It accounts for about 83 percent of total water use. Like other water consumers, agriculture tends to use more water each year.[42]

Vast amounts of water are needed to support the United States' agricultural economy. Amounts required to produce the food products that are consumed daily illustrate this point. Agricultural products represent more water use than the actual water molecules that enter our body. A person living on bread alone would actually use 300 gallons of water per day—the amount needed to grow the wheat for two and one-half pounds of bread.[43] About 120 gallons of water are needed to produce one egg. An eight-ounce serving of beef represents the consumption of an estimated 3,500 gallons. The steer from which the steak came may drink only 12 gallons a day, but the alfalfa or other forage it eats consumes enormous amounts of water. According to a University of California study, more than 4,500 gallons of water are needed to produce three meals a day for one person.[44]

The bulk of the water used in the production of agricultural products is used through irrigation. Despite water shortages appearing in some areas, such as the High Plains region, irrigation is increasing. In 1958 only 37 million farm acres were irrigated. By 1967, the figure was 44 million, and by 1977, according to definitions used in the Natural Resource Inventories, the total was 58 million acres. The rate of change to irrigation accelerated to 1.4 million acres a year during the last decade.[45] Virtually 90 percent of the groundwater withdrawals in the Ogallala aquifer High Plains region were used for agricultural irrigation.[46] The increase in irrigated land is depicted in Figure 2.

40. Adler et al., *supra* note 38.
41. U.S. DEP'T OF AGRIC., *supra* note 15, at 21.
42. *Id.*
43. PRINGLE, *supra* note 1, at 12.
44. Adler, et al., *supra* note 38, at 27.
45. U.S. DEP'T OF AGRIC., *supra* note 15, at 25.
46. U.S. GEOLOGICAL SURVEY, *supra* note 2, at 38-39.

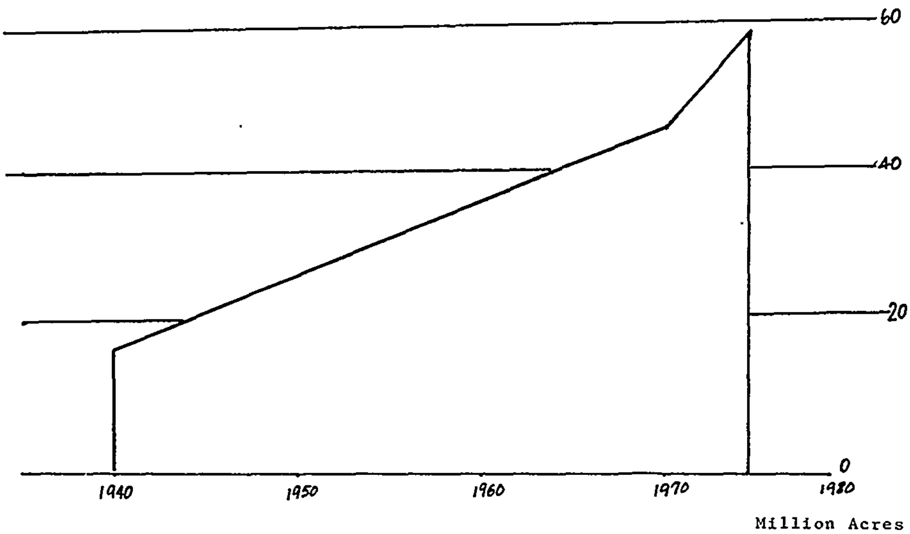

Figure 2. Increase in Irrigated Land
Source: United States Department of Agriculture

The West's increasing dependence on irrigation systems has led one observer to note: "The West never accepted the wisdom of God when he didn't put all the water there."[47] The agricultural economy has become dependent on mined water. Advancements of irrigation systems and techniques has led to predictions that two-thirds of Nebraska's cultivated farmland will be irrigated by the turn of the century.[48] The use of advanced irrigation systems where others failed is encouraged by state agricultural officials. A former University of Nebraska official called irrigation the state's "secret weapon" and predicted that the use of irrigation and the newest irrigation innovation, the center pivot system, could put Nebraska into the forefront of all agricultural states.[49]

The trend toward more irrigation may help Nebraska to realize this prediction in the short term. The benefits of research and its application to crops and irrigation has seen corn yields rise from 33 bushels per acre in the 1950s to high yields of 152 bushels per acre in 1971.[50] The trend toward more irrigation is accelerating in humid areas, like southern Georgia and along the Gulf Coast, where crops may need supplementary water in late summer.[51]

If irrigation is a weapon, it may be a two-edged sword that will eventually puncture the United States' farming balloon.[52] Not only has increased irriga-

47. Adler, et al., *supra* note 38, at 36.
48. PRINGLE, *supra* note 1, at 70-71.
49. *Id.* at 71.
50. Walsh, *supra* note 35, at 755.
51. U.S. DEP'T OF AGRIC., *supra* note 15, at 25.
52. PRINGLE, *supra* note 1, at 71.

tion caused overdrafts of limited groundwater supply resulting in various degrees of negative consequences on water availability, but agricultural irrigation has also been identified as a major contributor to an ever growing area of concern—the contamination of groundwater.[53] Contamination of supplies, coupled with steadily increasing use and demand, contributes greatly to the approaching water crisis.

Contamination Threats—The Exploiters

A wide range of activities can contaminate groundwater. Figure 3 depicts these activities, which are listed in Table 1. Conservationists and some agricultural scientists are alarmed at the effects of widespread irrigation on soils. Farmers have destroyed windbreaks of trees to create bigger fields for irrigation. This invites wind erosion. Irrigation has increased water erosion as well. Further, fertilizers, herbicides, and pesticides are washed into groundwater and surface water tapped by wells and used for drinking water.[54]

Agriculture is also the most widespread cause of "nonpoint source pollution," a result of storm runoff from the land. The runoff may carry with it particles of soil, organic wastes, and various chemicals applied to the land. The largest amount of agricultural pollutant is sediment. Sediment, in the form of suspended solids in waterways, screens out sunlight and inhibits the growth of aquatic plants and habitat. Sediment also settles to stream bottoms

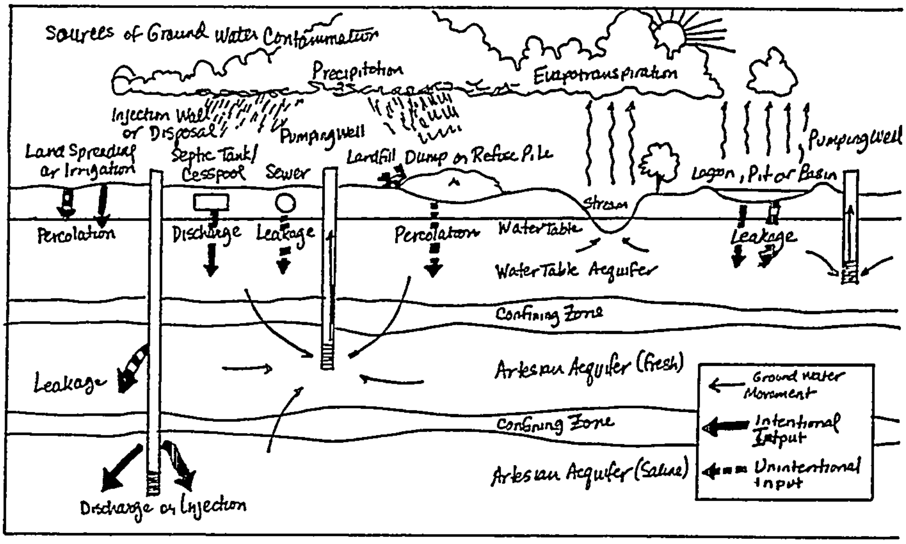

Figure 3. Sources of Groundwater Contamination
Source: United States Geological Survey

53. Henderson, Trauberman & Gallagher, *supra* note 9, at 1, 9.
54. Pringle, *supra* note 1, at 71.

Table 1

Major Source of Groundwater Contamination Due to Human Activity

Agricultural Practices:
—Irrigation return flows
—Fertilizer and pesticide applications
—Animal feedlots
Waste Disposals:
—Industrial wastewater impoundments
—Industrial and municipal solid waste landfills
—Industrial facility maintenance practices
—Septic systems
—Municipal wastewater systems
—Land spreading of sludge
—Mining wastes
—Waste disposal wells
Underground Storage Tanks:
—Leaks from gasoline storage tanks buried near filling stations
—Leaks from other petroleum product storage tanks
—Leaks from chemical or chemical waste storage tanks
Fuel Transportation and Use:
—Leaks or spills of fuels from pipelines, storage tanks, and vehicles
Well Operations:
—Brine disposal practices of oil and gas exploration operations
—Improper management of oil, gas, and water wells
—Abandoned water wells
Miscellaneous:
—Road salts
—Surface water pollution
—Air pollution

Source: Groundwater: Strategies for State Action

to form an oxygen-demanding sludge. Erosion from cropland contributes nearly half the total sediment pollution—about 760 million tons a year.[55]

Another major source of concern is the leaching of nitrates and salts that occur naturally in soils and are used in fertilizers. Salts and nitrates are leached into the available water supply, carried by irrigation wastes. Excess nitrates that are consumed by humans can cause a reduction of oxygen in the blood. Infants are most vulnerable to this sometimes fatal condition, also known

55. U.S. DEP'T OF AGRIC., *supra* note 15, at 30.

as the blue baby syndrome. This potentially serious health problem is likely to worsen as irrigation continues.[56]

Agricultural chemical fertilizers, pesticides, and animal feedlot wastes are sources of salts and nitrates. The use and reuse of irrigation waters can contaminate groundwater by percolating dissolved salts and agricultural chemicals directly to the water table from cultivated fields. The leaching of pesticides to groundwater in California's central valley, for example, has led to the closing of drinking water wells across the valley.[57]

Nitrates from nitrogen fertilizer are the most common kind of agricultural chemical contaminant. Livestock absorb the nitrates from grazing during feedlot operations, and then dispose of them through their wastes. An overconcentration of these wastes can overload the natural capacity of soil to assimilate organic materials. This allows the contaminants to enter groundwater and surface water.[58] Too many nutrients in water can overstimulate algal growth and make water unsuitable for use.[59]

The type of contamination that has received the most attention recently is the disposal of hazardous waste materials. Any substance that is toxic or otherwise a threat to life is considered a hazardous waste when discharged by human activity to the land, water, or atmosphere.[60] These contaminants can be harmful even in low concentrations to both humans and animals; the most feared and discussed potential result is the development of cancer in those who consume the contaminated water supply. In some heavily industrialized areas, the extent of the contaminated area and the toxic nature of the contaminants have ruled out the use of groundwater from shallow aquifers, and even some land areas.[61] The Love Canal area of Upper New York is perhaps the most memorable occurrence of land and water contamination as the result of hazardous waste disposal.[62]

Industrial wastewater impoundments are a source of serious groundwater contamination because of their numbers and their potential for leaking hazardous substances that are relatively mobile in the groundwater environment.[63] Industries generating the largest volumes of impounded liquid wastes are paper, petroleum and coal products, primary metals, and chemicals and allied pro-

56. PRINGLE, *supra* note 1, at 71. *See also* U.S. DEP'T OF AGRIC., *supra* note 15, at 31.

57. HENDERSON, TRAUBERMAN & GALLAGHER, *supra* note 9, at 16.

58. *Id.*

59. U.S. DEP'T OF AGRIC., *supra* note 15, at 31. Algal growth in municipal water supplies is stimulated during hot, dry summers and produces bad odor and taste at the tap. Moreover, because of population growth in the Southwest, this area of the country is beginning to experience heavy growth during late summer of specific blue-green algae that also produce toxins that can be injurious to human health. Fish kills and cattle kills are documented as being caused by these blue-green algae toxins. This particular problem has long been dealt with in the North and East by treating municipal water supplies with specific algaecides that retard the growth of the blue-green algae, thus reducing the production of the toxins.

60. U.S. GEOLOGICAL SURVEY, *supra* note 2, at 47, 58.

61. Miller, *Sources of Ground Water Pollution*, 10 EPA J. 17 (July, Aug. 1984).

62. HENDERSON, TRAUBERMAN & GALLAGHER, *supra* note 9, at 12.

63. Miller, *supra* note 61, at 17.

ducts. Contaminants from these sources include materials such as solvents, heavy metals, acids, and cyanide.[64]

Industrial and municipal solid waste landfills contain residential and commercial garbage. Liquid and solid industrial wastes such as sludges, scrap, solvents, and filter cakes are also included. Between 18,500 and 20,000 such facilities exist in the U.S., most of which are not lined or monitored. Many are very close to water supply wells. They leak more than 90 billion gallons of contaminated leachate per year into groundwater.[65] Leachate from such sites is a highly mineralized fluid containing such materials as chloride, iron, lead, copper, sodium, nitrates, and a variety of organic chemicals. The makeup of the leachate, however, depends upon the industry using the landfill or dump. Ninety percent of industrial wastes considered to be hazardous end up in landfills because it is the cheapest of waste management options.[66]

Septic tanks and cesspools rank highest in total volume of wastewater discharged directly to groundwater. They are the most frequently reported sources of groundwater contamination.[67] Septic tanks and cesspools discharge 800 billion gallons of sewage per year into the groundwater, affecting private wells used for drinking water.[68] Between 16 and 20 million single housing units in the U.S. dispose of domestic waste through septic tanks and cesspools. The contamination of groundwater with nitrates, phosphates, harmful bacteria, and solvents used to clean septic systems, such as trichloroethylene (TCE) has forced the abandonment of hundreds of drinking water wells.[69]

Municipal waste water follows one of three direct routes to groundwater: leakage from collecting sewers, leakage from a treatment plant during processing, and land disposal of the treatment plant effluent, or sludge. In addition, there are two indirect routes: effluent disposal to surface water bodies that recharge aquifers, and land disposal of sludge that is subject to leaching.[70]

Industrial and municipal sludges are often spread on cultivated lands to biodegrade their organic constituents. Sludge may also contain inorganics such as heavy metals, salts, and other substances. There have been few documented cases of hazardous levels of constituents of sewage affecting well water supplies, attributable largely to lack of study. Major industries that spread sludge are coal-fired utilities, textiles, canning, petroleum refining, and paper. Consequently, the threat to groundwater is worsening. The use of this waste disposal technique by industry has risen dramatically, however, and is projected by industry to continue.[71]

Mining activities and abandoned mines can cause groundwater contamination through seepage from tailing ponds (settling ponds for wastes mixed with

64. Powledge, *supra* note 3, at 200-06.
65. HENDERSON, TRAUBERMAN & GALLAGHER, *supra* note 9, at 12.
66. Miller, *supra* note 61, at 18.
67. *Id.*
68. HENDERSON, TRAUBERMAN & GALLAGHER, *supra* note 9, at 12-13.
69. *Id.* at 13. *See also* Miller, *supra* note 61, at 18.
70. Miller, *supra* note 61, at 18.
71. HENDERSON, TRAUBERMAN & GALLAGHER, *supra* note 9, at 13. *See also* Miller, *supra* note 61, at 18-19.

water), and runoff from waste piles. The discharge from mine drainage into soil, surface water, and injection wells also causes groundwater contamination. The most common contaminants are acids, dissolved solids, radioactive materials, and metals. Coal mining is a particularly significant cause of excess groundwater acidity. All types of surface and underground mines, however, contaminate groundwater to some extent. Because there are mines in every state in the U.S., mining wastes are a nationwide source of groundwater contamination. The recent inception of large-scale coal-mining operations in states such as North Dakota, Wyoming, and Montana make the groundwater in these states particularly vulnerable to contamination.[72]

Tens of thousands of wells nationwide are used for disposal of sewage, industrial waste, storm water, oil field brines, and irrigation return flows. About twenty of these wells inject wastes more than a thousand feet deep into saline aquifers.[73] Yet, these wells pose a relatively small contamination threat compared to the many shallow wells injecting contaminants into fresh water aquifers, or the tens of thousands of wells reinjecting oil field brines into deep geologic units that leak and percolate into fresh water aquifers.[74]

Percolation of liquids spilled at the land surface can be another serious threat if the ground is permeable and allows downward percolation.[75] The most common contaminants from these sources are hydrocarbons, such as gasoline and diesel fuel. These leak from service stations, storage and transfer facilities (particularly underground storage tanks), tank cars, and pipelines. Leaking underground gasoline storage tanks have been singled out as one of the major unregulated sources of groundwater contamination nationally. Underground storage of chemicals, chemical wastes, or petroleum products in steel or concrete tanks presents a potential hazard because metal corrosion or concrete deterioration may ultimately permit seepage of contaminants into an aquifer. According to a recent report, approximately 85 percent of the 1.4 million underground tanks storing gasoline are made of steel with no corrosion protection and were buried twenty years ago. Petroleum experts estimate 75,000 to 100,000 of these steel tanks leak and that the problem will increase two to threefold over the next five years.[76]

Improper installation, poor use, and abandonment of wells for extracting water, oil, and gas can cause groundwater contamination. A common form of contamination from poor well management and excessive pumping of water wells is saline intrusion into fresh water aquifers in coastal and arid areas. A 1971 study of the problem in California attributes the overdraft of groundwater with causing seawater intrusion in 262 groundwater basins. Saline intrusion also can occur in areas where poorly cased or improperly abandoned oil and gas wells act as conduits for saline water to travel into fresh water

72. Henderson, Trauberman & Gallagher, *supra* note 9, at 14.
73. *Id.*
74. Miller, *supra* note 61, at 19.
75. *Id.*
76. Henderson, Trauberman & Gallagher, *supra* note 9, at 14-15.

aquifers. Highly mineralized water extracted during oil and gas drilling and then reinjected, also can cause excessive groundwater salinity or hardness. In addition, improperly cased or abandoned wells provide a channel for other contaminants, such as oil and gas, to leak into groundwater from the surface or from shallow contaminated aquifers into deeper, clean aquifers.[77]

Highway and airport de-icing salts have contaminated groundwater in many areas of the U.S. snowbelt. Runoff and leaching from salt storage areas is the most significant problem. Dissolved de-icing salts trickling into the ground along roadsides also contribute to elevated levels of chloride in groundwater.[78]

Airborne contaminants, such as lead, cadmium, and mercury, are washed down into the soil and the underlying water table by rain. Of foremost concern today is "acid rain"—acidic gases in the atmosphere derived from natural sources such as volcanoes and forest fires and from man's activities, such as the burning of fossil fuels in power plants and motor vehicles.[79] These gases, through interaction with sunlight, water, and dust particles, can be changed chemically into strong acids, including sulfuric and nitric acids, and then reach the ground during rainfalls. In areas of low alkaline terrain unable to neutralize the acid, the water remains acidic as it moves through the hydrologic system by overland runoff and groundwater flow. Acidic water can dissolve naturally occurring elements in rocks and soils, such as aluminum, attaining concentrations that are toxic to aquatic life or vegetation. Acidic precipitation can also dissolve copper and lead pipes in public water supplies, leading to the danger of toxic effects from these metals. Reduction of acidity in streams, lakes, and groundwater supplies is a long-term and expensive undertaking.[80]

A recent incident in Michigan is illustrative. Chromium-laden dust from an industrial plant's ventilators was emitted into the air, settled to the ground, and was suspected of leaching into the water table after rainstorms. Acid rain can cause groundwater contamination by dissolving contaminants near the earth's surface and carrying them into groundwater. Pumping near the plant drew high levels of chromium into a well field.[81]

Polluted surface water can contaminate groundwater with any of the substances already mentioned. Surface waters often connect with groundwater; consequently, aquifers miles away from pollution sources can become tainted by polluted surface water. This is a particularly severe problem for sand and gravel aquifers associated with stream and river beds. For example, a municipal well in New York was abandoned after pollution from a nearby river dissolved iron and manganese in the underlying sand and gravel aquifer, causing unacceptably high levels of the metals in the well water.[82]

77. *Id.* at 15.
78. *Id.* at 16.
79. *Id.* at 16-17.
80. U.S. GEOLOGICAL SURVEY, *supra* note 2, at 61-62.
81. HENDERSON, TRAUBERMAN & GALLAGHER, *supra* note 9, at 16-17.
82. *Id.* at 17.

Extent of the Groundwater Contamination Problem

There has not been a comprehensive assessment of the extent of the groundwater pollution problem. It is clear, however, that groundwater contamination occurs nationwide. The Philadelphia Academy of Natural Sciences' 1983 study of groundwater suggested that 100 to 200 trillion gallons of groundwater are polluted. This is about 1 percent of all groundwater in the United States.[83] Environmental Protection Agency studies indicate this contamination will increase with time.[84]

Although a relatively small volume of groundwater is estimated to be contaminated, the health threat posed by such contamination is severe. Many of the most common groundwater contaminants, such as trichloroethylene (TCE), are potential carcinogens and may pose serious threats to public health. Contamination by such toxic synthetic organic compounds is estimated to have reached serious levels in thirty-four states. These and other contaminants have caused 2,200 private, public, and industrial wells to be closed in the United States. One study gives examples:

> Within the last few years, for example, public wells have been closed in 22 communities in Massachusetts, 16 in Connecticut, 25 in Pennsylvania, and 22 in New York. Similarly, over 100 private wells have been closed in New Jersey and 500 in Long Island. In the San Gabriel Valley in California, 39 public wells serving 400,000 people had to be shut down because of contamination by trichloroethylene, an organic chemical known to cause cancer in mice.[85]

Many of the contamination sources discussed above are found in every state in the nation. It is important to remember that the quality of groundwater can vary greatly even within a given area. For example, even if the water from a particular well is pure, the groundwater beneath an underground fuel storage tank just a few yards away could be heavily contaminated with gasoline. This makes it difficult to detect contamination or to assess its extent.[86] Further, this makes a determination of the seriousness and the proximity of the water crisis difficult.

Where Water Needs Collide

This century's longest oral argument before the United States Supreme Court was on *Arizona v. California*—a water case.[87] The Court usually hears about an hour of oral argument on a case. *Arizona v. California* was allotted twenty-two hours. In total, the work on the case lasted eight years. The Court heard

83. V. PYE, R. PATRICK, & J. QUARLES, GROUNDWATER CONTAMINATION 81-82 (1983).
84. HENDERSON, TRAUBERMAN & GALLAGHER, *supra* note 9, at 18.
85. *Id.* at 18.
86. *Id.* at 19.
87. 373 U.S. 546 (1963). *See* F. MOSS, THE WATER CRISIS 11 (1967).

340 witnesses, reviewed 25,000 pages of testimony, and reported findings in a volume of 433 pages. The final decree of the Court was handed down in 1964. Arizona won and obtained the right to 2.8 million acre-feet (one acre-foot equals 325,851 gallons) of water from the Colorado River.[88]

Arizona v. California symbolizes the mounting struggle to get water for competing uses and rival regions. Unlike frontier era showdowns, today's water wars are waged not by cattlemen and sodbusters armed with guns, but by lawyers, lobbyists, and politicians fighting in courtrooms and in the halls of Congress. The disputes are complex and the political and economic stakes enormous.[89] The Supreme Court's finding leaves southern California facing the prospect of water shortages.

The Central Arizona Project is to provide Phoenix, Tucson, and other metropolitan areas with water by a series of canals and aqueducts. The water Arizona will get, when the project is completed in the mid-1980s, now provides about one-half the water used by 13 million people in Southern California. In times of drought, it has been the only source of supply.[90]

Including California and Arizona, 17 million people in seven states and part of Mexico depend on the Colorado River. With fourteen major dams, it is the most controlled river system in the United States. It is also the most fought over river in the country. As the lifeblood of an arid and fast-growing region, its use will bring more conflict in the future.[91]

Competition for the river's water begins within the state of Colorado. Irrigators tap the young river before it reaches the first of several reservoirs. From those reservoirs, tunnels carry water through the mountains to the dry eastern slope of the Rockies, where it supplies such cities as Denver, Fort Collins, and Colorado Springs. It also irrigates thousands of acres of farmland. Western Colorado occupants are concerned that Denver's rapid growth will mean less water for their region, and intrastate lawsuits have erupted from time to time.[92] To combat the constant bickering, Colorado has attempted to mediate disputes by using the thirty-member Metropolitan Water Roundtable. The mediation effort has successfully avoided major disputes and kept litigation to a minimum.[93]

In addition to the east-west conflict within Colorado, competition for water looms within the Colorado River Basin region. A division of the Colorado River's water was arranged in 1922, signed by seven participating states, and later amended to allow Mexico a share. The Colorado River Compact gives first rights to the end of the line and last rights to the place of origin. Mexico claims 1.5 million acre-feet. States of the Lower Basin—Arizona, Nevada, and California—get the next 7.5 million acre-feet. The four Upper Basin states are also entitled to 7.5 million acre-feet.

88. Moss, *supra* note 87, at 11.
89. U.S. NEWS & WORLD REP., *supra* note 7, at 57.
90. *Id.* at 58.
91. PRINGLE, *supra* note 1, at 84.
92. *Id.* at 84.
93. U.S. NEWS & WORLD REP., *supra* note 7, at 59.

Thus, a total of 16.5 million acre-feet is allotted by the compact. The river, however, has not carried that much water in decades. The shares set by the compact were based on studies conducted before 1922, during an unusually wet period in the river's history. About 120 percent of the Colorado is committed; fortunately, thus far only about 85 percent of the river is used.[94]

As water needs increase in Colorado and the Upper Basin states, the compact seems more inequitable to residents of these states. It has been challenged a number of times, but the courts have upheld the legality of the compact, though some adjustments have been made, such as the Supreme Court's allowing the Central Arizona Project. This project decreased California's share while increasing Arizona's.[95]

Arizona now gets most of its water from aquifers that are being rapidly depleted, primarily by agricultural demands. Every year, Arizonans pump twice as much water out of the ground as nature returns to it. There is not enough water to meet all the needs of competing interests. Even with water from the Colorado River, Arizona farmers are losing the fight for survival.[96]

Under a plan enacted in 1980, farmers are required to pay sharply higher prices for water to irrigate their cotton and alfalfa fields, pecan groves, and citrus trees. The goal is to force farmers to sell their land for other uses by the year 2006. If a sufficient number of farmers do not sell, the state will buy farmland and retire it from production. Arizonans are betting that an influx of high technology industries will make up for the loss of agriculture, which now contributes two billion dollars a year to the Arizona economy.[97]

Other states have fought just as hard to gain and protect water rights. One encounter involves the state of New Mexico and El Paso, Texas—a city with a faltering water supply. El Paso has obtained water rights in southern New Mexico and plans to drill wells and pipe water across the border. In response to what it called "an act of piracy," New Mexico invoked a law that banned the export of water. A federal court, however, ruled in January 1983 that the law was an unconstitutional interference with interstate commerce. New Mexico lawmakers promptly passed new legislation to circumvent the court's decision. El Paso is suing to get the new law declared unconstitutional.[98]

Texas has also sought to replace supplies taken from the nearly depleted Ogallala aquifer in West Texas. To avoid a drained aquifer, Texas has considered importing water, preferably from the Mississippi River. Texas, however, has run into opposition from Arkansas and Louisiana. Even Texas voters have rejected proposals that would have financed a water-importation scheme, contending that it was not worth the estimated $20.6 billion price tag.[99]

Individuals and states have also fought to protect their asserted rights. In

94. PRINGLE, *supra* note 1, at 86-87.
95. *Id.* at 87.
96. U.S. NEWS & WORLD REP., *supra* note 7, at 58.
97. *Id.* at 58-59.
98. *Id.* at 59.
99. *Id.*

Sporhase v. Nebraska,[100] Sporhase owned 640 acres, 140 in Colorado and 500 in Nebraska. Sporhase's Nebraska land had a well 55 feet inside the state line which was used to irrigate corn on the Colorado land.[101] Sporhase contended he had notified the state of his intended use; further, a former owner had done the same thing without question. The state of Nebraska warned Sporhase to stop the use of the well across state lines. Nebraska outlaws piping water from the Ogallala aquifer to any state that in turn bans piping it into Nebraska. Colorado had such a ban.[102] Sporhase attempted to gain permission from Colorado to drill a well, but his application was turned down because state officials said the aquifer was already overused in his area. Sporhase defied Nebraska's warning, and the suit followed.[103]

Sporhase v. Nebraska is more than one farmer's fight to irrigate his land. A dozen western states have laws similar to Nebraska's, and most of them are in jeopardy. Seventeen briefs in opposition to Sporhase were filed, only one in favor, that coming from El Paso.[104]

The Court's ruling was not as broad as some opponents had feared, or as some supporters had hoped. The Court concluded that water is an article of interstate commerce. As such, Nebraska could not ban water exports to Colorado.

The seven to two ruling, however, upheld the rest of Nebraska's water law, including the state's right to regulate water use to ensure conservation. The Justices stated that a state still could ban water exports if the ban is narrowly tailored to the goal of conserving water. The Court sent the case back to Nebraska with instructions to remove the export ban from the state's water law. Sporhase still has not received a permit to irrigate his Colorado acres.[105]

American Indian tribes recently opened a new front in the nation's water wars that could upset the entire pattern of water use in the West. Indians have filed more than fifty lawsuits claiming rights to vast amounts of water they contend is due them under the terms of peace treaties signed more than a century ago. The lawsuits involve every major water-user system and source in the West.[106]

The problem goes back to 1908 when the United States Supreme Court decided *Winters v. United States*.[107] The Court ruled that tribal reservations were entitled to water even though no explicit quantities had been guaranteed by Congress. Indians were entitled to enough water to irrigate the reservations created by treaty or executive action in the late 1800s. The concept,

100. 458 U.S. 941 (1982).

101. Russakoff, "Farmer and 'Country Hick' Lawyer Upset Decades of Water Law," Washington Post, Sept. 12, 1982, at 10.

102. Russakoff, "Court Rules States Cannot Bar Water Transfers," Washington Post, July 3, 1982, § A, at 10.

103. *Id.* at 10-11.

104. *Id.* at 11. *See also* Russakoff, *supra* note 101, at 11.

105. Russakoff, *supra* note 101, at 11.

106. U.S. NEWS & WORLD REP., *supra* note 7, at 60.

107. 207 U.S. 564 (1908).

known as the *Winters* doctrine, established Indian water rights as "senior" to virtually every other use.[108]

If this concept is carried to the limit in, for example, Arizona, critics say the Indians would lay claim to five times the amount of water available to the entire state.[109]

State water laws in the West are based, for the most part, on the doctrine of prior appropriation. That is, one can simply appropriate water for a farm or mine as long as there is water in the stream. In a drought the state will cut off the most junior appropriators so that those with earlier rights may get their full appropriation.

Under state law, an individual must actually use water before his rights can be protected by the appropriation system. Indian rights, however, are reserved, meaning that they exist even if not previously exercised. Inevitably, those streams that have been most heavily appropriated are the most likely subjects of litigation.[110]

The Indians' rights exist only on paper, however. The water continues to be used by farms, mines, and cities in the Southwest. Though the tribes have won impressive court victories, thus far they do not have the financial resources to put their water rights to use. Congress and the executive branch are making only token contributions to their developments, according to critics.[111]

Oklahoma and Water

Oklahoma has prospered remarkably in the years since statehood, but the future is clouded by the unwelcome prospect of depletion of the state's natural resources. Oklahoma has plenty of water within the state's boundaries to meet all future requirements, but like other areas of the United States, the water is unevenly distributed. Eastern Oklahoma boasts an abundance of stream and groundwater resources and rainfall, while western Oklahoma is threatened by droughts and frequently suffers severe water shortages. All areas of the state have, at some time, been subject to spot shortages caused by water quantity and/or quality problems.[112]

Sharp escalations in population, industrial development, and irrigated agriculture, along with increased affluency and the consequent rise in standards of living, have placed heavy demands on Oklahoma's water resources. The Oklahoma Employment Security Commission forecasts a state population of 4.4 million by the year 2040 and over 6 million by 2090. As the population grows, so will water demands. All categories of water use will continue to escalate. It is imperative that Oklahoma plans for the optimum use of all

108. Ognibene, *Indian Water Rights Clouding Plans for the West's Economic Development*, NAT'L J. 1843 (Oct. 1982).

109. U.S. NEWS & WORLD REP., *supra* note 7, at 60.

110. Ognibene, *supra* note 108, at 1843.

111. *Id.*

112. OKLA. WATER RESOURCES BD., OKLAHOMA COMPREHENSIVE WATER PLAN 2 (1980).

potential supplies to assure adequate water to all parts of the state.[113] The Oklahoma Water Resources Board has predicted the following water resources and requirements for the year 2040: Western Oklahoma will have only half as much water as will be required, with nearly the same situation for the southwest part of the state. The north-central part of Oklahoma will be evenly balanced as to resources and requirements, with a similar situation existing in the south-central part. Central Oklahoma will fall short of meeting its requirements, while in the northeast, southeast, and east-central parts of the state, there will be more than adequate resources to meet the projected requirements. This information was publicized in the major newspapers of the state.

Agriculture is the state's leading economic activity. Eighty percent of the total irrigated land lies in western Oklahoma. The recent and rapid growth of irrigated agriculture, which is highly dependent on the Ogallala aquifer as a source of water, threatens to deplete the basin in the readily foreseeable future, as discussed earlier. If additional water supplies are not made available to sustain the agricultural stability of this productive region, the entire state will suffer severe economic consequences.[114]

Further aggravating the availability of fresh water in Oklahoma is the degradation in the quality of Oklahoma's stream and groundwater resources. Water quality is influenced by geology, climate, rural and urban development, wastewater treatment and disposal practices, storage in and diversions from lakes, and other practices applied to the operation of reservoirs. With increased discharges of wastes by municipalities, industries, and agriculture, further degradation of the waters can be expected, unless adequate quality management policies are adopted.

Industrial development and population growth are primarily responsible for the dramatic increases in manmade pollution in recent years. Oklahoma's extensive oil and gas production releases salt brine which contributes to the pollution of both stream and groundwater. New oil fields or wells may produce little or no brine, but fields nearing depletion may yield up to 100 barrels of salt water per barrel of oil. Agricultural runoff is increasingly polluting groundwater sources, despite attempts to control discharge.[115]

The United States Geological Survey also identifies three other water-quality issues in Oklahoma. The first is the seepage of natural brine along the Salt Fork, the Arkansas, the Cimmaron and the Red rivers and major tributaries. This seepage causes chloride concentration so that water from these streams is unusable for many purposes.[116] The second issue is the large sulfate concentrations resulting from dissolving of gypsum in the Washita River Basin. This has affected the suitability of the Washita River as a public supply. Foss

113. OKLA. WATER RESOURCES BD., SYNOPSIS OF THE OKLAHOMA COMPREHENSIVE WATER PLAN 7 (1980).

114. *Id.*

115. OKLAHOMA COMPREHENSIVE WATER PLAN, *supra* note 112, at 71-72.

116. U.S. GEOLOGICAL SURVEY, *supra* note 2, at 191.

Reservoir on the Washita River is used for a municipal supply, but the water must be treated by a desalination process.[117] Finally, a hazardous waste site near Criner, McClain County, has been included in the U.S. Environmental Protection Agency's National Priority List (1982). More than 20 million gallons of wastes, including pesticides, solvents, waste oils, and acids were disposed of in several surface impoundments and a drum burial area. The Oklahoma Department of Health detected groundwater pollution at the site in 1976. Remedial actions at the site have been pursued since then.[118]

After creation by the Oklahoma legislature, the Oklahoma Water Resources Board was given the task of developing a comprehensive plan for handling Oklahoma's water needs. Preliminary to the development of a plan, the state was divided into eight planning regions composed of counties, naturally grouped and demonstrating homogeneity of climate, hydrology, geography, economics, and demography.

In the development of the Oklahoma Comprehensive Water Plan, various alternatives were considered. Even those alternatives remotely capable of meeting Oklahoma's projected water demands were analyzed. Both transfer and nontransfer alternatives were considered, along with a no-action scenario evaluated to project the consequences if present trends were permitted to continue without material alteration.[119]

Most of the state's water resources are located in eastern Oklahoma, where abundant rainfall and runoff provide excellent potential for water resources development. The state has developed only a small portion of the estimated 34 million acre-feet of water which annually flows unused out of eastern Oklahoma into Arkansas and Louisiana, ultimately to the Gulf of Mexico. Water resources vastly exceeding any foreseeable demands remain available for development in this area.[120] On the other hand, central Oklahoma, which possesses the resources favorable for large-scale industrial expansion, is approaching the limit of development permitted by its available water resources and projected population growth is expected to place further pressure on existing supplies.[121] In western Oklahoma additional sources of water will soon be required to supplement or replace the depleting groundwater resources presently used to irrigate farmlands and to expand irrigation. It is estimated that some areas will expend their water supplies in twenty years or less, thus causing farmers to revert to dry-land farming.[122]

While alternatives to water transfer might individually and/or collectively provide some additional water, the amount is insignificant compared to Oklahoma's total future water needs. They are still, however, part of the state's overall planning efforts.[123]

117. *Id.* at 191.
118. *Id.*
119. SYNOPSIS OF THE OKLAHOMA COMPREHENSIVE WATER PLAN, *supra* note 113, at 11.
120. OKLAHOMA COMPREHENSIVE WATER PLAN, *supra* note 112, at 158.
121. *Id.*
122. *Id.*
123. SYNOPSIS OF THE OKLAHOMA COMPREHENSIVE WATER PLAN, *supra* note 113, at 11.

The Oklahoma Water Resources Board concluded from state and federal studies that the only feasible means of providing additional water to Oklahoma's water-deficient areas is by transferring surplus from eastern Oklahoma. The Army Corps of Engineers was the lead agency in developing draft plans and cost estimates for the central and eastern parts of the state, and the Bureau of Reclamation has the responsibility for planning conveyance facilities in western Oklahoma.[124]

The plan has met a great deal of opposition, and to date no work has taken place. The costs associated with pumping water has rendered the plan economically unfeasible at this time.[125] The cost has been estimated at $11 billion in 1978, which has given rise to opposition. Other estimates have placed the cost of the system at $21 billion in 1984 dollars. Most authorities agree the plan has to be modified and possibly expanded into a regional effort with neighboring states, to ever be approved by the legislature or voters.[126]

Little reliance can be had on the federal government to supply financial support in light of the federal government's withdrawal as primary financier of environmental projects.[127] Without development of a workable plan, the future of Oklahoma's development and economic destiny will remain highly questionable.

Conclusion

Without more water, booming urban hubs such as Los Angeles and Phoenix will stop growing and could even shrivel. The shift of industry from the Northeast and Middle West to the Sun Belt could grind to a halt, and agricultural empires might revert to desert. One thing is certain: Americans' abuse of water resources and their depletion of determinable supplies will lead to increasing competition for clean, plentiful supplies. As competition increases, Americans will learn that the era of cheap water, like the era of cheap energy, is over.

A path that must be promoted for the future is conservation. It is the key component in solving the water crisis and in avoiding future problems. It provides the equivalent of a vast untapped reservoir of clean, potable water. Yet, conservation programs are often ignored by politicians, community leaders, builders, planners, agriculture, and industry, and their unwillingness to pursue it seriously is a leading contributor to the water crisis.

Times of crisis have shown conservation can work and is easily grasped by the public. Both electricity and fuel conservation programs were readily accepted by Americans, and conservation efforts contributed greatly in the reduction of the crisis. Conservation programs would significantly aid in abating the water crisis on a local and a national basis. A comprehensive con-

124. *Id.* at 11-12.
125. U.S. Geological Survey, *supra* note 2, at 191.
126. "Water Will Go Where There is Money to Develop It, Water Expert Says," Sunday Oklahoman, Dec. 23, 1984, § A, at 21.
127. *Id.*

servation plan in the Ogallala aquifer region of Oklahoma and the other Ogallala states could readily sustain the aquifer's existence beyond the twenty- to thirty-year lifespan it has been given.

The failure to develop a conservation program is not solely the fault of the citizenry. No national water plan has ever materialized. More than twenty federal commissions and committees have reviewed the nation's water problems during the past half century. Local commissions number even more. Findings, conclusions, and recommendations are often inconsistent, sometimes even competing.

In Oklahoma's situation, the Oklahoma Water Resources Board's recommended water transfer system is both unfeasible and unrealistic. At upwards of $21 billion to construct today, it is hard, if not impossible, to consider the plan realistic. The legislature has provided support through appropriation of state funds of approximately $25 million as collateral to promote and assist the construction of water supply projects. With previous estimates in the billions of dollars to develop water projects, it is incomprehensible that this amount could come close to the required amount of capital. Oklahoma must make a stronger commitment to the development of a feasible and realistic plan.

Nationally, the same problem must be faced. With projects now running into the millions to billions of dollars, states cannot develop their own needed projects. A national clean water effort plan must immediately be implemented. The federal government must provide a consistent and comprehensive plan to overcome the water crisis that will affect the entire United States.

The challenges of allocating even scarcer water supply and bringing order to the pricing system guarantees that the escalating war over water will drag on for decades. If, however, water development, management, and conservation become the concerns of every American, the U.S. can avoid a water crisis.

When the well's dry, we know the worth of water.
—Benjamin Franklin
Poor Richard's Almanac

James J. Jackson